Amendments to the Claims:

This listing of claims will replace all prior versions, and listings of claims in the application. Applicants have submitted a new complete claim set showing any marked up claims with insertions indicated by underlining and deletions indicated by strikeouts and/or double bracketing.

Listing of Claims:

1. (Currently amended) ~~A method for approximating a number of tuples returned by a database query that comprises a set of predicates that each reference a set of database tables, the method comprising the steps of:~~

~~a) expressing the query as a query selectivity;~~

~~b) determining if the query is separable and if so separating the query selectivity to form a product of query selectivity factors;~~

~~c) if the query is not separable, atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression;~~

~~d) recursively performing steps b) - c) to determine a selectivity value for each query selectivity factor;~~

~~e) matching any conditional selectivity expression with stored statistics to obtain statistics that can estimate the selectivity of the conditional selectivity expressions and using the statistics to obtain an estimated selectivity value; and~~

~~f) combining the selectivity values obtained in step d) and the estimated selectivity values obtained in step e) to estimate the selectivity of the query~~

<u>A computer implemented method for approximating a number of tuples returned by a database query to optimize queries on a computerized database that comprises a set of predicates</u>

that each reference a set of database tables, the method comprising the steps of:

    a)   determining whether a first estimated selectivity value of the query is stored and returning the stored first estimated selectivity value to approximate the number of tuples returned by the query;

    b)   if a first estimated selectivity value of the query is not stored, expressing the query as a query selectivity;

    c)   determining if the query is separable;

    d)   if the query is separable:

        separating the query selectivity to form a product of query selectivity factors;

        recursively determining a selectivity value for each query selectivity factor;

        combining the selectivity values for each query selectivity factor to determine a second estimated selectivity value of the query;

    e)   if the query is not separable:

        atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression, wherein the atomically decomposing step is repeated to produce a plurality of alternative products that comprise corresponding conditional selectivity expressions;

        for each of the plurality of alternative products, matching a corresponding conditional selectivity expression with stored statistics to obtain statistics that can estimate a selectivity value of the conditional selectivity expression and using the statistics to obtain an estimated selectivity value of the conditional selectivity expression; and

        combining the estimated selectivity values of the conditional selectivity expressions corresponding to each alternative product to determine a third

estimated selectivity value of the query; and

f)	storing in memory either the second or third estimated selectivity value of the query based on whether the query is separable.

2.	(Currently amended) The method of claim 1 comprising the step of multiplying the second or third estimated selectivity value of the query by a Cartesian product of the tables referenced by the predicates to obtain a cardinality of the query.

3.	(Currently amended) The method of claim 1 wherein the step of separating the query selectivity to form a product of query selectivity factors is performed by separating the predicates that reference different sets of database tables to form a product of query selectivity factors that reference different sets of database tables.

4.	(Currently amended) The method of claim 1 wherein the each product formed in step ee) further comprises a query selectivity factor and wherein a selectivity value for each query selectivity factor is recursively determinedsteps b) f) are recursively performed to determine a selectivity value for the query selectivity factor in step e).

5.	(Currently amended) The method of claim 1 wherein steps cb) – ef) are recursively performed until a non-separable query selectivity that can only be decomposed into a single conditional selectivity expression results.

6.	Canceled.

7.	Canceled.

8. (Currently amended) The method of claim 1 comprising the step of associating an error with the third estimated selectivity value that is based on an accuracy with which the statistic matched with ~~the~~ a conditional selectivity expression can estimate the selectivity of the conditional selectivity expression.

9. (Currently amended) The method of claim 8 comprising the step of combining the error associated with each conditional selectivity expression to obtain an estimated error for the third estimated selectivity value ~~estimation~~ for the query.

10. (Original) The method of claim 1 wherein the stored statistics comprise histograms on results of previously executed query expressions.

11. (Currently amended) The method of claim 1 wherein the step of matching ~~the~~ a corresponding conditional selectivity expressions with stored statistics is performed by:

compiling a set of candidate statistics that can be used to estimate the selectivity value of the conditional selectivity expression; and

selecting candidate statistics to estimate the selectivity value of the conditional selectivity expression based on a selection criteria.

12. (Currently amended) The method of claim 11 wherein the selection criteria for a candidate statistic is determined by computing a number of independence assumptions that are made when the candidate is used to estimate the selectivity value of the conditional selectivity expression and the selection criteria is to select the candidate that results in the least number of independence assumptions.

13. (Original) The method of claim 11 wherein the selection criteria for a candidate statistic

is determined by comparing the candidate statistic with a base statistic over the same column as the candidate statistic and assigning a difference value to the candidate statistic based on a level of difference between the candidate statistic and the base statistic.

14.   (Original) The method of claim 11 wherein the step of compiling a set of candidate statistics is performed by including statistics that are on results of queries having the same tables referenced by the conditional selectivity expression or a subset of the tables referenced by the conditional selectivity expression and the same predicates over the tables referenced in the conditional selectivity expression or a subset of the predicates over the tables referenced in the conditional selectivity expressions.

15.   Canceled.

16.   (Currently amended) The method of claim 1̶5̶ wherein the step of <u>atomically</u> decomposing the query <u>selectivity</u> is done by exhausting every alternative way of <u>atomically</u> decomposing the query.

17.   (Currently amended) The method of claim 1̶5̶ wherein the step̶s̶ of <u>atomically</u> decomposing the query selectivity to form <u>a products</u> <s>that comprises a</s> <s>of</s> conditional selectivity expression̶s̶ is performed based on an optimizer search strategy.

18.   (Original) The method of claim 1 wherein the query is disjunctive and comprising the step of transforming the disjunctive predicates into conjunctive predicates by performing a De Morgan transformation on the disjunctive query.

19.   (Original) The method of claim 1 wherein the query comprises a GROUP BY predicate

over a grouping column and wherein the query is transformed prior to performance of the method steps to return a number of distinct values in the grouping column.

20. (Currently amended) The method of claim 19 wherein the step of <u>atomically</u> decomposing the query ~~selectivities~~<u>selectivity is</u> performed by considering decompositions that are induced by coalescing grouping.

21. (Currently amended) The method of claim 19 wherein the step of <u>atomically</u> decomposing the query ~~selectivities~~<u>selectivity</u> is performed by considering decompositions that are induced by invariant grouping.

22. (Original) The method of claim 1 wherein the stored statistics comprise histograms built over computed columns in a query result.

23. (Currently amended) For use with a database system, a computer readable medium having computer executable instructions stored thereon for performing method steps to approximate a number of tuples returned by a database query <u>to optimize queries on the database system</u> that comprises a set of predicates that each reference a set of database tables, the method comprising the steps of:

   a) ~~expressing the query as a query selectivity;~~

   ~~b)~~ ~~determining if the query is separable and if so separating the query selectivity to form a product of query selectivity factors;~~

   ~~c)~~ ~~if the query is not separable, atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression;~~

   ~~d)~~ ~~recursively performing steps b) — c) to determine a selectivity value for each query selectivity factor;~~

~~e) matching any conditional selectivity expression with stored statistics to obtain statistics that can estimate the selectivity of the conditional selectivity expressions and using the statistics to obtain an estimated selectivity value; and~~

~~f) combining the selectivity values obtained in step d) and the estimated selectivity values obtained in step e) to estimate the selectivity of the query~~

a) determining whether a first estimated selectivity value of the query is stored and returning the stored first estimated selectivity value to approximate the number of tuples returned by the query;

b) if a first estimated selectivity value of the query is not stored, expressing the query as a query selectivity;

c) determining if the query is separable;

d) if the query is separable:

separating the query selectivity to form a product of query selectivity factors;

recursively determining a selectivity value for each query selectivity factor;

combining the selectivity values for each query selectivity factor to determine a second estimated selectivity value of the query;

e) if the query is not separable:

atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression, wherein the atomically decomposing step is repeated to produce a plurality of alternative products that comprise corresponding conditional selectivity expressions;

for each of the plurality of alternative products, matching a corresponding conditional selectivity expression with stored statistics to obtain statistics that can estimate a selectivity value of the conditional selectivity expression and using the

statistics to obtain an estimated selectivity value of the conditional selectivity expression; and

combining the estimated selectivity values of the conditional selectivity expressions corresponding to each alternative product to determine a third estimated selectivity value of the query; and

f)   storing in memory either the second or third estimated selectivity value of the query based on whether the query is separable.

24.   (Currently amended) The computer readable medium of claim 23 comprising the step of multiplying the second or third estimated selectivity value of the query by a Cartesian product of the tables referenced by the predicates to obtain a cardinality of the query.

25.   (Currently amended) The computer readable medium of claim 23 wherein the step of separating the query selectivity to form a product of query selectivity factors is performed by separating the predicates that reference different sets of database tables to form a product of query selectivity factors that reference different sets of database tables.

26.   (Currently amended) The computer readable medium of claim 23 wherein the each product formed in step ~~c~~e) further comprises a query selectivity factor and wherein a selectivity value for each query selectivity factor is recursively determined~~steps b) – f) are recursively performed to determine a selectivity value for the query selectivity factor in step c)~~.

27.   (Currently amended) The computer readable medium of claim 23 wherein steps c~~b~~) – ~~e~~f) are recursively performed until a non-separable query selectivity that can only be decomposed into a single conditional selectivity expression results.

28.   Canceled.

29.   Canceled.

30.   (Currently amended) The computer readable medium of claim 23 comprising the step of associating an error with the third estimated selectivity value that is based on an accuracy with which the statistic matched with the a conditional selectivity expression can estimate the selectivity of the conditional selectivity expression.

31.   (Currently amended) The computer readable medium of claim 30 comprising the step of combining the error associated with each conditional selectivity expression to obtain an estimated error for the third estimated selectivity value estimation for the query.

32.   (Original) The computer readable medium of claim 23 wherein the stored statistics comprise histograms on results of previously executed query expressions.

33.   (Currently amended) The computer readable medium of claim 23 wherein the step of matching the a corresponding conditional selectivity expressions with stored statistics is performed by:

        compiling a set of candidate statistics that can be used to estimate the selectivity value of the conditional selectivity expression; and

        selecting candidate statistics to estimate the selectivity value of the conditional selectivity expression based on a selection criteria.

34.   (Currently amended) The computer readable medium of claim 33 wherein the selection criteria for a candidate statistic is determined by computing a number of independence

assumptions that are made when the candidate is used to estimate the selectivity value of the conditional selectivity expression and the selection criteria is to select the candidate that results in the least number of independence assumptions.

35.   (Original) The computer readable medium of claim 33 wherein the selection criteria for a candidate statistic is determined by comparing the candidate statistic with a base statistic over the same column as the candidate statistic and assigning a difference value to the candidate statistic based on a level of difference between the candidate statistic and the base statistic.

36.   (Original) The computer readable medium of claim 33 wherein the step of compiling a set of candidate statistics is performed by including statistics that are on results of queries having the same tables referenced by the conditional selectivity expression or a subset of the tables referenced by the conditional selectivity expression and the same predicates over the tables referenced in the conditional selectivity expression or a subset of the predicates over the tables referenced in the conditional selectivity expressions.

37.   Canceled.

38.   (Currently amended) The computer readable medium of claim 3723 wherein the step of atomically decomposing the query selectivity is done by exhausting every alternative way of atomically decomposing the query.

39.   (Currently amended) The computer readable medium of claim 3723 wherein the steps of atomically decomposing the query selectivity to form a products that comprises a of conditional selectivity expressions is performed based on an optimizer search strategy.

40.   (Original) The computer readable medium of claim 23 wherein the query is disjunctive and comprising the step of transforming the disjunctive predicates into conjunctive predicates by performing a De Morgan transformation on the disjunctive query.

41.   (Original) The computer readable medium of claim 23 wherein the query comprises a GROUP BY predicate over a grouping column and wherein the query is transformed prior to performance of the method steps to return a number of distinct values in the grouping column.

42.   (Currently amended) The computer readable medium of claim 41 wherein the step of atomically decomposing the query ~~selectivities~~selectivity is performed by considering decompositions that are induced by coalescing grouping.

43.   (Currently amended) The method of claim 41 wherein the step of atomically decomposing the query ~~selectivities~~selectivity is performed by considering decompositions that are induced by invariant grouping.

44.   (Original) The computer readable medium of claim 23 wherein the stored statistics comprise histograms built over computed columns in a query result.

45.   (Currently amended) ~~An apparatus~~ computer system comprising one or more processors and memory for approximating a number of tuples returned by a database query to optimize queries on a computerized database that comprises a set of predicates that each reference a set of database tables comprising:

    a)   ~~means for expressing the query as a query selectivity;~~

~~   b)   means for determining if the query is separable;~~

    c)   ~~means for separating the query selectivity to form a product of query selectivity~~

factors if the query is separable;

~~d)   means for atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression if the query is not separable;~~

~~e)   means for recursively performing steps b)   d) to determine a selectivity value for each query selectivity factor;~~

~~f)   means for matching any conditional selectivity expression with stored statistics to obtain statistics that can estimate the selectivity of the conditional selectivity expressions and means for using the statistics to obtain an estimated selectivity value; and~~

~~g)   means for combining the selectivity values obtained in step d) and the estimated selectivity values obtained in step e) to estimate the selectivity of the query~~

   a)   means for determining whether a first estimated selectivity value of the query is stored and means for returning the stored first estimated selectivity value to approximate the number of tuples returned by the query;

   b)   means for expressing the query as a query selectivity if a first estimated selectivity value of the query is not stored;

   c)   means for determining if the query is separable;

   d)   means for separating the query selectivity to form a product of query selectivity factors if the query is separable, further comprising:

            means for recursively determining a selectivity value for each query selectivity factor;

            means for combining the selectivity values for each query selectivity factor to determine a second estimated selectivity value of the query;

   e)   means for atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression if the query is not separable, wherein atomically decomposing is repeated to produce a plurality of alternative products that comprise corresponding conditional selectivity expressions, further comprising;

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means for matching a corresponding conditional selectivity expression for each of the plurality of alternative products with stored statistics to obtain statistics that can estimate a selectivity value of the conditional selectivity expression and means for using the statistics to obtain an estimated selectivity value of the conditional selectivity expression; and

means for combining the estimated selectivity values of the conditional selectivity expressions corresponding to each alternative product to determine a third estimated selectivity value of the query; and

f)   means for storing in memory either the second or third estimated selectivity value of the query based on whether the query is separable.

46.   (Currently amended) ~~A method for approximating a number of tuples returned by a database query that comprises a set of predicates that each reference a set of database tables, the method comprising the steps of:~~

~~a)   expressing the query as a query selectivity;~~

~~b)   determining if the query is separable and if so separating the query selectivity by separating the predicates that reference different sets of database tables to form a product of query selectivity factors that reference different sets of database tables;~~

~~c)   if the query is not separable, repeatedly atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression to generate alternative products and wherein one of those products is selected to estimate the selectivity of the query;~~

~~d)   recursively performing steps b) - c) to determine a selectivity value for each query selectivity factor;~~

~~e)   matching any conditional selectivity expression with stored statistics to obtain statistics that can estimate the selectivity of the conditional selectivity expressions by:~~

~~i)   compiling a set of candidate statistics that can be used to estimate the selectivity of the conditional selectivity expression;~~

~~ii)   selecting candidate statistics to estimate the selectivity of the conditional selectivity expression based on a selection criteria; and~~

~~iii)   using the statistics to obtain an estimated selectivity value~~

A computer implemented method for approximating a number of tuples returned by a database query to optimize queries on a computerized database that comprises a set of predicates that each reference a set of database tables, the method comprising the steps of:

a)   expressing the query as a query selectivity;

b)   determining if the query is separable;

c)   if the query is separable:

> separating the query selectivity by separating the predicates that reference different sets of database tables to form a product of query selectivity factors that reference different sets of database tables;

> recursively determining a selectivity value for each query selectivity factor;

> combining the selectivity values for each query selectivity factor to determine a first estimated selectivity value of the query;

d)   if the query is not separable:

> atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression, wherein the atomically decomposing step is repeated to produce a plurality of alternative products that comprise corresponding conditional selectivity expressions;

> for each of the plurality of alternative products, matching a corresponding conditional selectivity expression with stored statistics to obtain statistics that can estimate a selectivity value of the conditional selectivity expression by:

compiling a set of candidate statistics that can be used to estimate the selectivity value of the conditional selectivity expression;

selecting candidate statistics to estimate the selectivity value of the conditional selectivity expression based on a selection criteria; and

using the statistics to obtain an estimated selectivity value of the conditional selectivity expression; and

combining the estimated selectivity values of the conditional selectivity expressions corresponding to each alternative product to determine a second estimated selectivity value of the query; and

e)   storing in memory either the first or second estimated selectivity value of the query based on whether the query is separable.

47.   (Original) The method of claim 46 wherein the selection criteria for a candidate statistic is determined by computing a number of independence assumptions that are made when the candidate is used to estimate the selectivity of the conditional selectivity expression and the selection criteria is to select the candidate that results in the least number of independence assumptions.

48.   (Original) The method of claim 46 wherein the selection criteria for a candidate statistic is determined by comparing the candidate statistic with a base statistic over the same column as the candidate statistic and assigning a difference value to the candidate statistic based on a level of difference between the candidate statistic and the base statistic.

49.   (Currently amended) The method of claim 46 wherein the step of compiling a set of candidate statistics is performed by including statistics that are on results of queries having the same tables referenced by the conditional selectivity expression or a subset of the tables

referenced by the conditional selectivity expression and the same predicates over the tables referenced in the conditional selectivity expression or a subset of the predicates over the tables referenced in the conditional selectivity expressions.

50.   (Currently amended) The method of claim 46 wherein ~~the~~ each product formed in step d~~e~~) further comprises a query selectivity factor and wherein a selectivity value for each query selectivity factor is recursively determined~~steps b) – f) are recursively performed to determine a selectivity value for the query selectivity factor in step e~~).

51.   (Currently amended) The method of claim 46 wherein steps b) – d~~f~~) are recursively performed until a non-separable query selectivity that can only be decomposed into a single conditional selectivity expression results.

52.   (Currently amended) The method of claim 46 comprising the step of associating an error with the second estimated selectivity value that is based on an accuracy with which the statistic matched with ~~the~~ a conditional selectivity expression can estimate the selectivity of the conditional selectivity expression ~~its selectivity~~.

53.   (Currently amended) The method of claim 52 comprising the step of combining the error associated with each conditional selectivity expression to obtain an estimated error for the second estimated selectivity value ~~estimation~~ for the query.

54.   (Currently amended) For use with a database system, ~~A~~a computer readable medium having computer executable instructions stored thereon for performing method steps to ~~approximating~~approximate a number of tuples returned by a database query to optimize queries on the database system that comprises a set of predicates that each reference a set of database

tables, the method comprising the steps of:

~~a)   expressing the query as a query selectivity;~~

~~b)   determining if the query is separable and if so separating the query selectivity by separating the predicates that reference different sets of database tables to form a product of query selectivity factors that reference different sets of database tables;~~

~~c)   if the query is not separable, repeatedly atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression to generate alternative products and wherein one of those products is selected to estimate the selectivity of the query;~~

~~d)   recursively performing steps b) - c) to determine a selectivity value for each query selectivity factor;~~

~~e)   matching any conditional selectivity expression with stored statistics to obtain statistics that can estimate the selectivity of the conditional selectivity expressions by:~~

~~i)   compiling a set of candidate statistics that can be used to estimate the selectivity of the conditional selectivity expression;~~

~~ii)   selecting candidate statistics to estimate the selectivity of the conditional selectivity expression based on a selection criteria; and~~

~~iii)   using the statistics to obtain an estimated selectivity value~~

a)   <u>expressing the query as a query selectivity;</u>

b)   <u>determining if the query is separable;</u>

c)   <u>if the query is separable:</u>

    <u>separating the query selectivity by separating the predicates that reference different sets of database tables to form a product of query selectivity factors that reference different sets of database tables;</u>

    <u>recursively determining a selectivity value for each query selectivity factor;</u>

combining the selectivity values for each query selectivity factor to determine a first estimated selectivity value of the query;

d) if the query is not separable:

atomically decomposing the query selectivity to form a product that comprises a conditional selectivity expression, wherein the atomically decomposing step is repeated to produce a plurality of alternative products that comprise corresponding conditional selectivity expressions;

for each of the plurality of alternative products, matching a corresponding conditional selectivity expression with stored statistics to obtain statistics that can estimate a selectivity value of the conditional selectivity expression by:

compiling a set of candidate statistics that can be used to estimate the selectivity value of the conditional selectivity expression;

selecting candidate statistics to estimate the selectivity value of the conditional selectivity expression based on a selection criteria; and

using the statistics to obtain an estimated selectivity value of the conditional selectivity expression; and

combining the estimated selectivity values of the conditional selectivity expressions corresponding to each alternative product to determine a second estimated selectivity value of the query; and

e) storing in memory either the first or second estimated selectivity value of the query based on whether the query is separable.

55. (Original) The computer readable medium of claim 54 wherein the selection criteria for a candidate statistic is determined by computing a number of independence assumptions that are made when the candidate is used to estimate the selectivity of the conditional selectivity expression and the selection criteria is to select the candidate that results in the least number of

independence assumptions.

56.   (Original) The computer readable medium of claim 54 wherein the selection criteria for a candidate statistic is determined by comparing the candidate statistic with a base statistic over the same column as the candidate statistic and assigning a difference value to the candidate statistic based on a level of difference between the candidate statistic and the base statistic.

57.   (Currently amended) The computer readable medium of claim 54 wherein the step of compiling a set of candidate statistics is performed by including statistics that are on results of queries having the same tables referenced by the conditional selectivity expression or a subset of the tables referenced by the conditional selectivity expression and the same predicates over the tables referenced in the conditional selectivity expression or a subset of the predicates over the tables referenced in the conditional selectivity expressions.

58.   (Currently amended) The computer readable medium of claim 54 wherein ~~the~~ each product formed in step d<u>e</u>) further comprises a query selectivity factor and wherein <u>a selectivity value for each query selectivity factor is recursively determined</u>~~steps b) — f) are recursively performed to determine a selectivity value for the query selectivity factor in step e)~~.

59.   (Currently amended) The computer readable medium of claim 54 wherein steps b) – d<u>f</u>) are recursively performed until a non-separable query selectivity that can only be decomposed into a single conditional selectivity expression results.

60.   (Currently amended) The computer readable medium of claim 54 comprising the step of associating an error with the <u>second</u> estimated selectivity value that is based on an accuracy with which the statistic matched with ~~the~~ <u>a</u> conditional selectivity expression can estimate <u>the</u>

selectivity of the conditional selectivity expression ~~its selectivity~~.

61.   (Currently amended) The computer readable medium of claim 60 comprising the step of combining the error associated with each conditional selectivity expression to obtain an estimated error for the <u>second estimated</u> selectivity <u>value</u> ~~estimation~~ for the query.